

Monteverde, Costa Rica:
Balancing Environment and Development

Erin Cavanagh

Borlaug-Ruan Intern 2005

Monteverde Institute

Monteverde, Costa Rica

Acknowledgements

Dr. Norman Borlaug, John Ruan, Ambassador Quinn and the World Food Prize Foundation- Thank you very much for choosing me as a 2005 Borlaug-Ruan Intern. I could not have asked for a more wonderful experience.

Lisa Fleming- You were an incredible resource to me before I left for Costa Rica and a great support system while I was there. Thank you for providing me ample guidance and friendship.

Jason Niebler- I could not have asked for a better supervisor. Thank you for giving me the freedom to follow my own path on my projects and for making me feel so welcome at MVI.

Elsa, Bruce, Manrique, Marlene, and all the Monteverde Institute staff- Thank you very much for all your help during my time in Costa Rica. My internship would not have run nearly as smoothly without all of you.

Cristina Rubio- Thank you so much for helping me with my Spanish. I enjoyed class with Meghan and you greatly.

Amy Rhodes, Andrew Guswa, Ilona, Mai, Marilee, and June- I greatly enjoyed working on my project with Smith. Thank you for allowing me to spend so much time with you all in the lab.

Silvia Newell- Thank you for providing me with such great background information on the greywater situation in Costa Rica and for allowing me input on the Reedbed Manual.

Chris Heaney- Working with you on the Quality Assessment Plan for the MVI Environmental Health Laboratory allowed me to learn a great deal. Thank you for allowing me to assist you.

Michael Garcia and Sustainable Futures students- I cannot imagine my internship in Costa Rica without all of you. You provided me with so much encouragement and friendship that I greatly appreciate. The “survivors” will always live on!

Roy and Yorlenny Vargas Vega, Nidia, Maria Paula- Thank you so much for allowing me to live in your home. You made me feel welcome in Costa Rica and a part of the family. I miss you all very much.

My family- Thank you for allowing me to undertake this great opportunity and for the weekly phone calls! Your support meant the world to me.

Two years ago I would have never imagined that I would see the glow of molten lava contrasting against the night sky, stand on the top of a mountain looking at the Pacific Ocean hundreds of miles away, or become the daughter of a family other than my own. I began my journey through the World Food Prize program in February 2004 when my friend Lindsey Negaard told me that she would be interning in Mexico for the World Food Prize. After explaining to me all the different steps necessary to compete for an internship, she asked me if I was interested in continuing the program for Bettendorf High School. Before writing my paper on water efficiency in rice production and obtaining background information on starvation, I was ignorant of the number of hungry people worldwide that can be saved through science. The presenters at the World Food Prize Symposium in October 2004 impacted me to desire to see these parts of the world myself. When I was selected to intern at the Monteverde Institute in Monteverde, Costa Rica, I realized that I had a great deal to learn about Costa Rica and its culture before I even left the country. The next two months taught me lessons that I will never forget and introduced me to a people and a culture that I will treasure for the rest of my life.

Costa Rica, meaning rich coast in Spanish, is a beautiful country sandwiched between Nicaragua to the north and Panama to the south. Although Costa Rica is a very small country, encompassing only 51,100 sq km, it is one of the most well-educated countries in Central America with 96% of its approximately 4 million people being able to read and write over age 15. (CIA World Fact Book) Because of abolishing its military in 1948, Costa Rica has gained a reputation of a safe, peaceful country with strong democratic roots. (“Our Democracy: An Overview”) Although Costa Rica’s economy has been booming recently because of ecotourism, traditionally Costa Ricans worked in the agricultural sector. Even today, twenty percent of its population is employed in agriculture. (CIA World Fact Book) The Costa Rican people, or “ticos” as they are referred to commonly, are an extremely friendly and caring population that emphasizes retaining traditions such as the Catholic religion. (“Our Democracy: An Overview”)

Since the arrival of the Quakers until present day, Monteverde is special because of the town’s strong emphasis on conservation. In protest to the peacetime draft after World War 2, several Quakers from Fairhope, Alabama served time in jail. Afterward, approximately fifty North American Quakers made the trip to Monteverde, Costa Rica to

make a new life in 1951. (Nadkarni). The Quakers chose Costa Rica because Costa Rica's peaceful values matched their own. Believing that there is power in creation and all life is interrelated, the Quakers wanted to live simply by farming and producing dairy products. Because the Quakers appreciated the value of nature, they practiced conservation techniques such as, "saving forested areas, allowing natural windbreaks to regenerate, and planting trees in pastured areas." (Nadkarni) Conservation continues to be important and successful in Monteverde because of "its relative inaccessibility, careful monitoring by scientists, well-trained guides, and cohesive, socially responsible local community." (Honey)

Monteverde's economic situation has changed drastically over the past fifty years. After World War 2, people in Costa Rica were encouraged to participate in cattle ranching in addition to traditional farming. This trend was also followed in Monteverde where bare hills can be seen frequently as a result of cattle ranching. But as conservation became more important and ecotourism became a more solvent option for Monteverde, the people switched its focus from agriculture to ecotourism. "It is estimated that 65 to 70 percent of the area's income now comes from tourism- up from just 10 percent in the late 1980s." (Honey) With the increased number of tourists in the area, the population of Monteverde has grown tremendously over the past 20 years. In fact, "according to a 1992 survey, the population of the 3 communities, Monteverde, Santa Elena, and Cerro Plano, grew by more than 130 percent between 1984 and 1992 and 600 of the area's 3500 residents had moved in over the previous five years." (Honey) Because utility companies have not been able to supply their services at this pace, blackouts can occur along with water shortages.

One of the most recent developments in Monteverde is the formation of its municipal government. Until two years ago, Monteverde was governed as a district in the province of Puntarenas and had no local form of government. (Nadkarni) In general, the Monteverde Zone refers to the communities around Santa Elena, Cerro Plano, and Monteverde. The municipal government was formed in 2003, led by Superintendente Municipal, or in English, Mayor Marconi Suarez. (Garcia) Similar to the United States, a term is four years, however, the mayor can be re-elected as many terms as the public sees fit. The municipal government has five basic members and two extra members

called vocals that are substitutes in the event that other members miss a vote. Because of not having localized government in the past, zoning in the area virtually does not exist. In response to this problem, the municipal government is drawing up a regulation plan to map out residential areas, business zones, and conservation land and also to design limitations for buildings. (Garcia) Beyond problems with city planning, paving the roads is a controversial topic in Monteverde because of past failures. A short time ago the municipality paved the road that goes down a steep hill from Cerro Plano to Santa Elena. Because the construction company did not design the road correctly and failed to use adequate layers of materials, the road quickly started washing away and now is full of potholes. If the national government decided to pave the highway to Monteverde, the transportation time to the town would be cut significantly, encouraging more tourists to come to the area. Although more people would surely come, a benefit to businesses, the roads would also allow people to leave the area within a day, greatly hurting the hotels and restaurants. An even higher number of tourists in the area could also cause more environmental damage.

Monteverde has both physical and biological diversity because of its unique position on the Tilaran mountain range. Because Monteverde is a tropical montane cloud forest, one of the ecosystems in most danger of extinction, conservation has become a key component of life in the Monteverde Zone. (Nadkarni) When considering how much forest has been acquired and put under protection, conservation in Monteverde is a huge success. There are several different preserves in the Monteverde area that were formed to protect the unique species in Monteverde such as the Resplendant Quetzal. In fact, “by 1998, the Monteverde Conservation League’s Children’s Forest Reserve included about 18,000 hectares, the Monteverde Cloud Forest Reserve included about 10,500 hectares, and the Santa Elena Reserve included 310 hectares, making a total of about 29,000 hectares in the Monteverde Reserve Complex.” (Nadkarni) This emphasis on conservation mirrors an overall national awareness of the importance of conserving land. Although the worldwide average of land preservation is only three percent, over twenty-five percent of Costa Rica’s land has some form of protection. These levels of protection range from areas that are completely closed to the public to national parks, the first of which was created in 1969. (Honey)

Several organizations have taken up the goal of promoting conservation and providing environmental education in the Monteverde area. Over the past fifty years, scientists from all around the world have come to do research because of the unique habitat that Monteverde provides. They began coming in the late 1960s, staying at the one or two small hotels in the area or at a research station. Formal research greatly increased in the 1980s, reached its highest level in the early 1990s, and then took a steep drop. Because of the Organization for Tropical Studies, Monteverde has been a very popular area for biology students to come and study tropical montane habitats. (Nadkarni) Although many research projects and studies have taken place in Monteverde, the lack of a centralized means of coordinating these results makes it difficult to find adequate information that the public can use to improve the area or that scientists could rely on as background for their projects.

The Monteverde Institute is probably the most capable of providing history, a research laboratory, and educational courses to the public. Established in 1986 by twenty-eight residents of Monteverde from North America, the Monteverde Institute (MVI) serves the community by teaching courses in tropical ecology, conservation, agroecology, and Spanish language for high school and undergraduate college students from the United States. The proceeds from those “courses provide over half of MVI’s income” while funding “culturally-enriching activities for the Monteverde community that focus on education and sustainable development” (Nadkarni). One of the programs I was most impacted by was the Sustainable Futures program taught by Michael Garcia. In 1995, the program was created to teach students in architecture and landscape architecture about sustainable development and to have the students design for local organizations. This year, students from Maryland and New York aided the municipality in reconfiguring city planning and traffic control for Santa Elena, designing a brochure and other media to promote the Sendero Pacifico (or Pacific Slope trail), mapping out a conservation easement on the Los Llanos field station, and making design improvements to the Santa Elena Reserve. All of these projects are strongly backed by the Monteverde Institute because of their importance to the conservation of the area. A conservation easement on the Los Llanos field station makes the land legally protected, preventing construction on the areas that are biologically important to species such as the bell birds.

Conservation easements have become necessary because the results of deforestation in the area have “been both economically and ecologically disastrous.” (Forsyth) Because of the wet and dry seasons in Monteverde, pastures become easily eroded. During the dry season, the sun makes the land very dry and the plant life that would prevent erosion gets crushed by cows. Then during the rainy season, heavy rains wash the soil away. In addition, deforestation has isolated the reserves, and even though the animal populations have the preserved land, the scattered reserves are not large enough to sustain the population. (Forsyth) MVI is trying to find a way to connect forested properties together to have a biological corridor from the mountains all the way down to the Pacific Ocean. The biological corridor becomes important when considering that half of Costa Rica’s 820 bird species migrate from the mountains to the oceans as the seasons change. Sendero Pacifico, another project worked on by the Sustainable Futures group, is a path that runs from the Los Llanos field station down to another field station in San Luis, a town that is about a half hour drive down the mountain from Monteverde. Because the Santa Elena and Monteverde areas have become congested with tourists going to the Monteverde Cloud Forest Reserve and other attractions, the goal is to spread out the tourism to the San Luis area.

Because of the boom in ecotourism, life in Costa Rica and Monteverde has completely changed. In order to be classified as ecotourism, the trip must: “be travel to natural destinations, have minimal impact on the environment, build the traveller’s environmental awareness, provide direct financial benefits for conservation, provide financial benefits and empowerment for local people, respect local culture, and support human rights and democratic movement.” (Honey) Unfortunately, very few ventures advertised as ecotourism actually meet these requirements. Ecotourism began attaining popularity after conservationists realized they could not protect the environment by shutting people out of it. Therefore, environmentalists turned to options that make it economically viable for local people to want to protect their resources. Monteverde in the early 1950s had nearly no visitors besides scientists doing research and only one pension. By 1998, Monteverde’s tourism market contained at least 15 medium to large hotels and even more pensions. At this point, there were about 450 rooms available in Monteverde with 1000 beds. (Nadkarni)

By courting ecotourists to come to Costa Rica, the country is tapping into a huge economic market. “By the 1990s, tourism vied with oil as the world’s largest legitimate business. In 1995, worldwide spending on travel totalled \$3.4 trillion, and it was expected to reach \$4.2 trillion by the year 2000. Tourism itself is the world’s number one employer, accounting for 10 percent of jobs globally.” (Honey) For many third world countries, ecotourism provides a way to make conservation build up its economy while preserving its natural resources.

Yet ecotourism has had both a positive and a negative impact on Monteverde and the country as a whole. The main attraction in Monteverde is the Monteverde Cloud Forest Reserve (MCFR) and therefore, the reserve is extremely important to the community’s economic future. The majority of businesses in the area see enhanced revenues because of the tourists that come to the area to see the MCFR. In fact, “the economic impact of this industry on a community of 4000 inhabitants was estimated at 5 million dollars in 1992, of which only 13 percent was spent in the MCFR” (Nadkarni) The average worker benefits from working in the tourism industry rather than in agriculture because of increased social status and better pay on the average. More important than simple financial benefit is the fact that ecotourism makes it disadvantageous for a community to participate in “destroying its environmental resource base”, and therefore, conservation is deemed as a high priority. (Cater) Along with gaining employment in the many jobs associated with the tourism industry, locals gain power by being able to procure the right to efficient use of the national park lands and can profit by charging tourism companies that use the land traditionally owned by families. (Honey)

Although ecotourism is economically advantageous for Costa Rica, there are many negative aspects to allowing this type of industry to be a major part of the economic plan for the country. The main problem with allowing ecotourism to play a central role in the economy is that tourism is a cyclical industry. “Ecotourism, like tourism, frequently depends on extraneous factors beyond its control: natural disasters, AIDS and other diseases, civil wars, the stock market, hijackings, high levels of crime, and other media coverage.” (Honey) As seen in Monteverde, the rapidly increasing number of people in an area because of tourism can be unsustainable if infrastructure is

lacking. For example, the amplified traffic in Monteverde has caused road deterioration and the average price of property has risen from fifteen to twenty dollars per meter cubed. Because prices in Monteverde are set for tourists as the main consumer, native Costa Ricans cannot afford to pay for land and other basic goods. The area even lacked a waste collection system until it was started by local institutions in 1993. (Nadkarni) Some economists even wonder how financially beneficial it is to have thriving ecotourism. According to a USAID study, “in Costa Rica, which by the early 1990s was the number one overseas ecotourism destination for United States travellers, half of every tourist dollar never left the United States, and only twenty cents actually went into the local economy.” (Honey) Nat Scrimshaw, former director of MVI, recognized that although the whole community benefits from ecotourism, it established higher inequities in wealth as well, because although some people have the resources to actually open the businesses, most of the people are brought in to work in menial jobs. Perhaps the most astonishing disadvantage to ecotourism is that the industry can actually damage the land that it wants to protect. If not properly controlled, high number of tourists in a condensed area will degrade the land and destroy wildlife. Examples of this environmental damage are seen in Manuel Antonio National Park, the Cabo Blanco Wildlife Reserve, and the Carara Biological Reserve. (Honey)

The Monteverde Cloud Forest Reserve is an example of an ecotourism attraction that has not suffered the ecological damage seen in other areas of the country. The Quakers originally founded this reserve by “setting aside about one-third of their original purchase to protect their watershed, the headwaters of the Rio Guacimal.” (Nadkarni) At a price of one colon per year for ninety years, the Tropical Science Center has leased the property from the Quakers to protect it. (Nadkarni) Initially tourism to the MCFR was extremely light; however, today almost 50,000 visitors annually come to the private reserve. (Nadkarni) Earning \$850,000 per year, the reserve brings in more revenue than all of the national parks in Costa Rica put together. (Honey) With all these visitors brings the risk of ecological damage. According to Anita Pleumarom, “to generate substantial revenue...the number of tourists has to be large, and that inevitably implies great pressures on ecosystems.” (Honey) In order to prevent ecological damage to the reserve’s land, the Tropical Science Center limited the number of people that can be in

the park at any one time, and began to “harden” the most-frequently used paths with wood and brick.

When I first arrived in Costa Rica, I began researching the problem of greywater and the lack of waste treatment in the region. Greywater is the water that comes from sinks, laundries, and showers that would be treated in the United States, but in Costa Rica is simply piped out into the street and eventually makes its way into the soil and local streams. Blackwater, or used toilet water, flows to a septic system on each household’s property. Unfortunately, each resident is responsible for disposing of its own blackwater and is expected to take the water to a treatment center hours away in Puntarenas or San Jose. Therefore, it is likely that many residents also dump their blackwater into a stream or bury it in the soil. (Newell 1) The impact of the lack of the waste management infrastructure in Monteverde is tremendous. Because of the chemicals found in soaps, greywater causes environmental contamination and health risks. (Dallas 1). Higher chemical content in local streams impacts farmers tremendously because they use local river water to irrigate their crops. Therefore, the food grown in Costa Rica has been affected by the chemicals in laundry detergents, shampoos, etc.

In attempt to solve this problem, a Ph. D. candidate from Murdoch University, Australia, Stewart Dallas, worked at the Monteverde Institute from 1999-2003 developing a reedbed model for greywater treatment. (Newell 2) Currently, nine reedbeds treat greywater in the Monteverde area with varying levels of success. According to his model, Dallas writes, “reedbeds are subsurface flow constructed wetlands for the biological treatment of wastewater with the principal advantages of avoidance of odour, mosquitoes, and public contact as the wastewater level is maintained below the media surface” (Dallas 2). First, greywater flows underground from the structure to a greasetrap that separates the water from the solids. Then, the water flows through a t-valve into the reedbed at root level. The reedbed is dug out of the ground, lined with plastic, and filled with either cut-up plastic bottles or small rocks with a 5 to 35 mm diameter. Planted on the reedbed are Job’s tears, hydroponically-grown plants with a deep root system to maximize the cleaning of the wastewater. (Dallas 1) After flowing through the reedbed, water is usually directed to another reedbed, an aeration pond, or an absorption trench. Even though these further treatment options are available, the

greywater should be purified to the United States' standards for fecal coliform and biological oxygen demand for irrigation water after going through the first reedbed. (Newell 2) Although these reedbed systems do work when properly constructed and maintained, the main problem in Monteverde is Costa Rica's low maintenance culture.

In order to aid the locals in caring for their reedbeds, Silvia Newell, a 2004-2005 Fulbright Scholar and Ph. D. candidate at Stanford University, Daniel Craig, a volunteer at MVI in March-June 2005, and Scott Harlow, an annual volunteer at MVI in October-May, wrote a manual that documents the reedbeds in the area and gives maintenance tips. The authors hope that the Reedbed Manual promotes water treatment education in Monteverde while encouraging others to install their own reedbed system. During the authors' research, they discovered that "almost all of the current installations are not being maintained or monitored properly" (Newell 2). Once the Reedbed Manual is translated into Spanish, it will be distributed to all of the owners of the reedbed systems and will hopefully help those owners repair their reedbeds. In order to aid Silvia in her efforts, I edited the Reedbed Manual for clarity, grammar, and, with the information I gathered about reedbed systems, looked for accuracy in instructions. Also, I helped to educate visitors and volunteers at MVI on wastewater treatment by taking them on a tour of the reedbed systems at MVI and the Community Arts Center and explaining how the systems work. By spreading water treatment education, MVI hopes to decrease the amount of greywater that ends up in the streams. Consequently, water quality will be improved and the risk of contaminating crops with chemicals will be reduced.

After finishing the editing on the Reedbed Manual, I worked for three weeks with Chris Heaney, a Ph. D candidate at the University of North Carolina at Chapel Hill in order to create a Quality Assessment Plan for the MVI Environmental Health Laboratory. The purpose of this document is to aid MVI in becoming a certified laboratory by MINAE, an organization similar to the EPA. Having a Quality Assessment Plan assures standards for laboratory procedure and therefore, will aid MVI in moving towards certification. Right now MVI has to send all of its samples to San Jose and the United States in order to have them tested. Even though the samples are analyzed by certified laboratories, the results themselves are not certified because the MVI Environmental Health Laboratory does not have certified experimentation methods. If MVI became

certified, a more standard system of testing local water and soils could be implemented, improving the health standards in the area. MVI could also gain an extra avenue of income through testing fees. In order for the plan to work, the Quality Assessment Plan has to be a living document. Each time that a new professor comes to MVI, he will be required to write in the plan his biography, the goals and purposes of his project, a very detailed description of his methods, his results, etc. A major problem at MVI is that professors come here to research, obtain a large amount of data, and then leave with that data without providing that information to MVI as well. Having a Quality Assessment Plan requires that MVI receive that information. With the data, MVI will have a composite of the work that they have helped to achieve and will receive more grants for their work. Having high standards for visiting professors will guarantee that quality professors are doing research here. The major part of the plan that I contributed to was coming up with safety standards and cleaning procedures for the laboratory. Also I created a grid that has to be completed each time an experiment is performed in order to keep track of exactly what chemicals are being used in experiments in case an accident were to occur. In addition to the Quality Assessment Plan, Chris and I worked on the inventory of the MVI Environmental Health Laboratory. Monteverde's sister city in Estes Park, Colorado has an association that is trying to help MVI get a grant from Hach Environmental Corporation. Therefore, Chris and I found a probe from Hydrolab, a partner to Hach, that will greatly increase the efficiency of water testing in streams by having instant data readouts and tests several different aspects of water quality. I wrote an explanation of the reasons why MVI needs the specific equipment and who will be maintaining/using the equipment because the sister city association needs that info to try to get the grant. Should MVI receive these grants, the quality of its laboratory would improve greatly.

Upon completion of the Quality Assessment Plan, I began to study hydrology of the Monteverde Zone. One of the reasons why maintaining Monteverde's ecosystem, a tropical montane cloud forest, is important is that the forest captures water from mist and fog and adds to the area's water resources. (Nadkarni) Monteverde has three distinct seasons of weather throughout the year: the dry season from February to April, the wet season from May to October, and the transitional season from November to January.

(Rhodes 2) The Intertropical Convergence Zone (ITCZ) is a low pressure weather pattern that causes the drastic differences in rainfall type and quantity throughout the year in Monteverde. When the ITCZ is located directly above Costa Rica during the wet season, Monteverde receives seventy percent of its annual precipitation. (Rhodes 1) Because the ITCZ travels from the tropics and causes convective precipitation, rain that comes from cumulus or cumulonimbus clouds, precipitation during the wet season has its lightest isotopic value. (Nadkarni) Rain has its heaviest isotopic value during the transitional season because of orographic rain events such as mist and more localized rain.

(Nadkarni) Understanding the amount of rain that falls in each season and where that rain originates from is important when attempting to quantify available water resources. Since more people have arrived in Monteverde and pressure on resources has increased, more attention has been given to the amount of water in the area. Amy Rhodes, a geology professor from Smith College, states that, “recent work has shown evidence that regional land use and climate change may lead to increased cloud-base elevations. This would reduce the orographic component of precipitation to the hydrologic cycle, affecting both ecology and water resources. Because of the potential for reduced water supply and the reality of increased demand, a better understanding of the role of orographic precipitation is essential for sustaining the vibrant Monteverde region.”

(Rhodes 2) In addition, because drinking water is being acquired from local streams in the Monteverde Cloud Forest Reserve and Bajo del Tigre, any increase in the demand for water could reduce the amount of water in the streams, reducing the dilution of greywater discharge and agricultural runoff in the river. (Rhodes 1)

For my last month at MVI, I assisted two professors, Amy Rhodes and Andrew Guswa, and four students, Ilona Johnson, Mai Kobayashi, June Yeung, and Merilie Reynolds, from Smith college in their hydrology project based out of MVI. Smith College has been studying the hydrology of Monteverde for the past five years. The focus of this year’s study is attempting to discover how much of Monteverde’s water resources are coming from orographic or convective rainfall based on isotopic weight of water samples. (Rhodes 2) The sample area is the Rio Guacimal watershed. The upland areas of the watershed are primary and secondary forest, including the Monteverde Cloud Forest Reserve and Bajo del Tigre, with little or no contact by humans. Developed land

is mainly located in Santa Elena and Cerro Plano and follows the main road that travels to the Monteverde Cloud Forest Reserve. (Rhodes 1) All rivers from the upper elevations come together into the Rio Guacimal near San Luis at a lower elevation. During an interview with Merilie Reynolds and Mai Kobayashi, they explained their project. At site 200 on two rivers, Quebrada Sucia and Quebrada Cuecha, the Smith College girls conducted event sampling by collecting a sample of water at one hour increments or at thirty minute increments if it was raining. At these same testing times, they would test turbidity of the water, or how much chemicals are in the water and from where.

(Kobayashi) If the turbidity levels increased with rain, Mai and Merilie knew they were seeing signs of agricultural runoff; if turbidity decreased with rain, they knew that the increased dilution of chemicals meant that those chemicals were coming from a point source such as a house. At three points on the upper watershed, Quebrada Cuecha, Quebrada Sucia, and Rio Guacimal, and two on the lower watershed in San Luis, they measured discharge in order to try to understand what proportion of the water that ends up in San Luis comes from each of the upper elevation streams. By measuring the depth of the river, width of the river, and velocity of the water passing through, they hope to use the numbers to create a relationship and then a model for the volume of the river.

(Kobayashi) In attempt to achieve their goal of finding the source of precipitation, the Smith College students collected one sample per week from all the river sites in the watershed, two open sites with no canopy cover at MVI, and two open sites with canopy cover at MVI. By measuring isotopic weight, they can know whether rain in Monteverde is coming from the tropics or from local storms. Finally, they collected samples to take back to Smith in order to analyze the chemical composition of the water. Based on results from the past five years, Smith has concluded that, “chemical loads are two to five times more concentrated at the downstream locations. Highest concentrations are seen at QS-200, the site with the highest population density.” (Rhodes 1) Also, comparing the chemistry of the water between upstream water sites and downstream sites displays the impact of development on water quality. Therefore, reserves such as the Monteverde Cloud Forest Reserve and Bajo del Tigre have intrinsic value by limiting the amount of pollution that enters the watershed. (Rhodes 1)

My project complemented the Smith College project by analyzing the sediment load in local streams and adding that information to its chemical composition numbers. My purpose was to view the effect of a storm on the sediment composition of a river, understand the impact of community development on sediment load, and develop insight on where chemicals and runoff are coming from. I hypothesized that because both the Rio Guacimal and Quebrada Sucia are below populated areas, these test sites (RG 200 and QS 200) will have higher sediment levels than the Quebrada Cuecha test site (QC 200). Also, heavy rainfall will cause all of these sites to have higher sedimentation loads.

I had three main sites that I tested: Quebrada Cuecha 200 (QC 200), Rio Guacimal 200 (RG 200) and Quebrada Sucia (QS 200). Quebrada Cuecha is located about one hundred yards from the MVI. The surrounding area is predominantly secondary forest that is not affected by human activity. Once the Quebrada Cuecha passes underneath the bridge near the Community Arts Center, it is renamed the Rio Guacimal. The Rio Guacimal does see effects of human activity because of surrounding agriculture and the dirt road that passes above it. Therefore, QC 200 is considered my control: land unaffected by human activity. Because these two sites are on the same river, the differences in sediment load are especially important. Quebrada Sucia (QS 200) is located in between the Cerro Plano and Santa Elena areas. This area is extremely populated and therefore, the Quebrada Sucia is affected by the road and also greywater from the many houses in the area.

The main focus of the study was on the Quebrada Cuecha 200 and Rio Guacimal 200 sites. For every sample taken at one of these two sites, I took a sample at the other site during a close time period in order to allow for comparability. I weighed the filter paper using a balance and recorded the weight along with the total volume of water. Using a vacuum, I suctioned the water through the various beakers and the sediment remained on the filter. After a filter was full, I placed it into the oven, measured a new filter, and put it in the other filter's place. After the oven completely dried the filters, I measured each filter again on the balance. I recorded each of the differences in weight of the filters on a spreadsheet, added them together to find the total amount of sediment, and then proportioned the result to discover how much sediment would be in a sample of one liter of water.

The results of my sedimentation in streams study show a dramatic increase in sediment load at Quebrada Sucia 200 and Rio Guacimal 200 during a storm event. In contrast, the sediment loads at Quebrada Cuecha 200 remained fairly constant. Also, even though the Quebrada Cuecha 200 and Rio Guacimal 200 sites are a very short distance apart, sediment readings in the Rio Guacimal were at one point almost ninety times greater than in the Quebrada Cuecha. There are several possible explanations for these differences. There is a pipe upstream of the Rio Guacimal 200 site that, during a rain storm, dumps extremely brown water into the river. This pipe possibly comes from an aeration pond or a farm. Also, when the unpaved road near the Community Arts Center floods, sediment from the road and from up the hill runs into the river. Therefore, the affect of the Monteverde population is certainly evident when analyzing the increased sediment levels. The Quebrada Sucia's base sediment levels were slightly higher than that of the Quebrada Cuecha and Rio Guacimal. Therefore, when looking back to the hypothesis, the sites downstream of a populated area (QS 200 and RG 200) had significantly higher sediment levels during a storm event than their base levels, however, Quebrada Cuecha remained fairly constant in every sample.

This study is important when considering food security because people in lesser-developed countries need access to an abundance of clean water as well as healthy food. Especially in the dry season, water shortages are common because of the increased number of visitors in Monteverde. Businesses and community members are competing for water resources. With the development of a model by Smith College, Monteverde could assess the amount of water available and distribute it accordingly. Farmers must have access to enough water in the streams for irrigation in order to be able to harvest a bountiful crop. However, even if there is access to water, using water that is highly polluted with chemicals from greywater to irrigate is dangerous to people's health and could negatively affect the soil.

Interning in Costa Rica was undoubtedly the most rewarding and life-altering experience that I have ever had. Talking to my Costa Rican mother, Yorlenny, about the roles that women have in the country and sharing stories with my friend Marco Vargas about the differences between the American and Costa Rican cultures expanded my knowledge of the world and made me realize how isolated I was from different

viewpoints. One of the most fascinating parts of the internship was analyzing the weaknesses in Costa Rican infrastructure and seeing how important the distribution of resources is in the area. Although I have always been interested in alternative energy sources, my experience in Costa Rica has opened my eyes to a greater number of sustainable options when designing communities and allocating resources. Because of the importance of protecting the environment, I reconsidered my future career plans and now plan to study environmental law. My positive time in Costa Rica has propelled me to consider studying abroad for a year in college in order to obtain an international spin on my undergraduate business degree. Yet, perhaps the most important aspect of this trip was recognizing my desire to serve people. During my law career, I want to benefit small communities such as Monteverde by advising them on options to make the best use of their resources. The growing interconnectedness of the world's nations makes it even more important that citizens reach out to help others in the global community that are struggling. The World Food Prize has recognized this need and in the future I plan to work towards this objective as well.

Works Cited

- Cater, Erlet. (1994). "Ecotourism in the Third World: Problems and Prospects for Sustainability."
- CIA World Fact Book. (Retrieved March 2005). "Costa Rica"
www.cia.gov/cia/publication/factbook/print/cs.html
- 1 Dallas, Stewart, Ho, Goen, and Mathew, Kuruvilla. "The Development and Operation of Low-Cost Reedbeds for Greywater Treatment in Costa Rica, Central America."
- 2 Dallas, Stewart, Scheffe, Brian, and Ho, Goen. (July 2004). "Reedbeds for Greywater Treatment: Case Study in Santa Elena-Monteverde, Costa Rica, Central America."
- Forsyth, Adrian. "The Costa Rican Connection." *Equinox*. March/April 1988
- Garcia, Michael. (August 2005). Personal Communication. Sustainable Futures Program. Monteverde Institute. Monteverde, Costa Rica.
- Honey, Martha. Ecotourism and Sustainable Development: Who Owns Paradise?. Washington, D.C.: Island Press. 1999.

Kobayashi, Mai and Reynolds, Merilie. (July 2005). Personal Communication. Smith College. Northampton, Massachusetts.

Nadkarni, Nalini and Wheelwright, Nathaniel. Monteverde: Ecology and Conservation of a Tropical Cloud Forest. New York, NY: Oxford University Press. 2000.

1 Newell, Silvia. (June 2005). Personal Communication. 2004 Fulbright Scholar. Monteverde Institute. Monteverde, Costa Rica.

2 Newell, Silvia, Craig, Dan, and Harlow, Scott. (May 2005). Reedbed Manual.

“Our Democracy: An Overview” (Retrieved July 2005).
<http://www.infocostarica.com/general/democracy.html>

1 Rhodes, A. L., A. J. Guswa, S. Dallas, E. M. Kim ('02), S. Katchpole ('02), and A. Pufall, in press. Water quality in a tropical montane cloud forest, Monteverde, Costa Rica. In: Bruijnzeel, L. A., Juvik, J., Scatena, F. N., Hamilton, L. S., and Bubb, P. (eds.), *Forests in the Mist: Science for Conservation and Management of Tropical Montane Cloud Forests*, University of Hawaii Press.

2 Rhodes, A. L., A. J. Guswa, and S. E. Newell ('04), in press. Using stable isotopes to identify orographic precipitation events in Monteverde, Costa Rica. In: Bruijnzeel, L. A., Juvik, J., Scatena, F. N., Hamilton, L. S., and Bubb, P. (eds.), *Forests in the Mist: Science for Conservation and Management of Tropical Montane Cloud Forests*, University of Hawaii Press.